Pflügers Arch – Eur J Physiol (1996) 431[Suppl]:R207–R208

Determination of the femoral and pelvic geometrical parameters that are important for the hip joint contact stress: differences between female and male

B. Kersnič[1] · A. Iglič[2,3] · V. Kralj-Iglič[3] · A. Jaklič[2] · F. Srakar[1,4] · F. Pernuš[2] · V. Antolič[1,4]

[1] Department of Orthopedics, Medical Faculty, Zaloška 9, Ljubljana, Slovenia
[2] Faculty of Electrical and Computer Engineering, Tržaška 25, Ljubljana, Slovenia
[3] Institute of Biophysics, Medical Faculty, Lipičeva 2, Ljubljana, Slovenia
[4] J. Stefan Institute, University of Ljubljana, Jamova 39, Ljubljana, Slovenia

Abstract. The difference between male and female femoral and pelvic geometry was studied by considering some geometrical parameters such as interhip distance, inclination of the crista iliaca, diameter of the femoral head and centre-edge angle of Wiberg. The values of these parameters were determined for 79 healthy female and 21 healthy male subjects. Standard anterior-posterior radiographs were used and processed by the computer-aided system. The results show some important sex differences in femoral and pelvic geometrical parameters which determine the hip joint contact stress.

Key words: hip joint - pelvic shape - pelvic parameters

Introduction

The hip joint is one of the most important joints of the human body. It was shown recently that a long lasting too high contact stress in the articular surface of the hip joint accelerates degenerative changes in the joint [1]. In the past, most of the attention has been paid to the influence of the femoral geometry on the contact stress in the hip joint articular surface [6,7]. However, it was indicated that the pelvic geometry is important too [3,4]. Therefore in this work the femoral and pelvic geometry is studied, which can be described by some chosen parameters (Fig. 1) such as the distance between the inner acetabular rims (A), the distance between the two most lateral points on the crista iliaca (C), the pelvis height which is defined as the vertical distance between the femoral head center and the corresponding most cranial point on the pelvis (H), the femoral head radius (r), and the centre-edge angle of Wiberg (ϑ_{CE}). Some of the geometrical parameters of the pelvis were measured previously [8], however, in this work only those which influence the hip joint contact stress are considered [3,4]. Using 100 anterior-posterior radiographs of 79 healthy female and 21 healthy male subjects it was our aim to study whether there are any statistically significant differences between the female and the male population in femoral and pelvic geometrical parameters which determine the hip joint articular stress.

Correspondence to: V. Antolič, J. Stefan Institute, University of Ljubljana, Jamova 39, SI-61000 Ljubljana, Slovenia

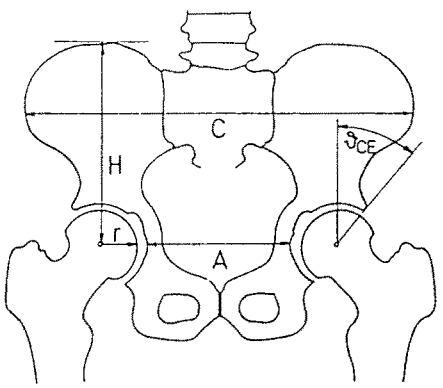

Fig. 1. Schematic presentation of the pelvis and hip. The characteristic parameters are marked: the distance between the inner acetabular rims (A), the distance between the two most lateral points on the crista iliaca (C), the pelvis height which is defined as the vertical distance between the femoral head center and the corresponding most cranial point on the pelvis (H), the femoral head radius (r), and centre-edge angle of Wiberg (ϑ_{CE}).

Materials and methods

The AP radiographs were taken from the archives of the Department of Orthopaedics, Medical Faculty, from 1985 on. Only radiographs that were found to be normal were taken into account. The radiographs were processed by the computer-aided system [5]. The above geometrical parameters (Figure 1) were determined for each subject. The average value of the pelvis height (H), the femoral head radius (r), and the centre-edge angle (ϑ_{CE}) was determined taking into account the average of the right and the left side of each subject. The data were analyzed by using statistical methods. As some of the obtained distributions significantly differ from normal distributions the female and male populations were measured by comparing their median values. Since the sizes of the female and male populations being different, the Mann-Whitney test comparing the median values was used to determine the differences between the two populations.

Results and Discussion

It can be seen from Figs. 2-5 that some distributions can not be considered as normal. Note that the female and the male populations are normalized separately.

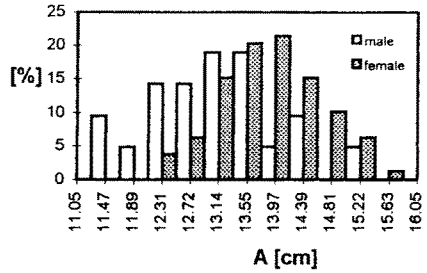

Fig. 2. Histogram of the distance between the inner acetabular rims (A). The median values of the two populations 14.05 cm (female) and 12.94 cm (male) exhibit statistically significant difference ($P<10^{-4}$).

Fig. 2 indicates that the distance between the inner acetabular rims is statistically significantly larger in the female population than in the male population.

Fig. 3 indicates that the femoral head radius is statistically significantly smaller in the female population than in the male population. The Wiberg angle was also analyzed showing that there is no statistically significant difference between the two populations.

The parameters describing the inclination of the crista iliaca (C/A) and the proportion of the pelvis (A/H) were also introduced to study the pelvis shape. It is shown that there is statistically significant difference between the two populations with respect to the inclination of the crista iliaca (Fig.4) and pelvic proportion (Fig.5).

The above results can be evaluated by using the results of mathematical models describing biomechanical status of the human hip [3,4] which show that larger interhip distance importantly increases the contact stress in the hip joint. It was also calculated that smaller femoral head radius and smaller Wiberg angle increase contact stress in the hip joint [2,6,7]. At given value of A the parameters C/A and A/H were found to have considerably less effect on the contact stress in the hip joint. Taking this into account it can be concluded that regarding the hip joint contact stress the geometry of the female pelvis, having larger distance between the inner acetabular rims and smaller femoral head radius, is less favourable than the male pelvis geometry.

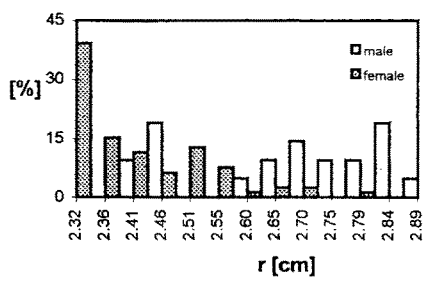

Fig. 3. Histogram of the femoral head radius. The median values of the two populations 2.38 cm (female) and 2.68 cm (male) exhibit statistically significant difference ($P<10^{-4}$).

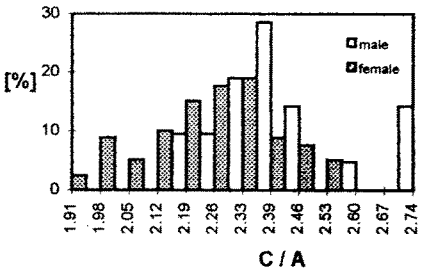

Fig. 4. Histogram of the ratio between the pelvis width (C) (defined as the distance between the two most lateral points on the crista iliaca) and the distance between the inner acetabular rims (A). The median values of the two populations 2.28 (female) and 2.36 (male) exhibit statistically significant difference (P=0.0204).

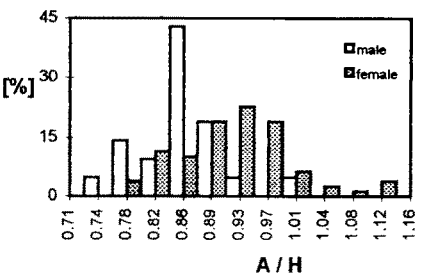

Fig. 5. Histogram of the ratio of the distance between the inner acetabular rims (A) and the pelvis height (H). The median values of the two populations 0.93 (female) and 0.83 (male) exhibit statistically significant difference ($P<10^{-4}$).

Acknowledgements :

We thank Dr. L. Kragelj-Zaletel for advices regarding to statistical methods.

References

1. Hadley NA, Brown TD, Weinstein SL (1990) The effects of contact pressure elevations and aseptic necrosis on the long-term clinical outcome of congenital hip dislocation. J Orthop Res 8: 504-513.
2. Iglič A, Kralj-Iglič V, Antolič V, Srakar F, Stanič U (1993) Effect of the periacetabular osteotomy on the stress on the human hip joint articular surface. IEEE Trans Rehab Engr 1: 207-212.
3. Iglič A, Srakar F , Kralj-Iglič V, Antolič V (1994) The influence of pelvic shape on the stress distribution on the articular surface of the human hip joint. Zdrav Vest 63: 727-728.
4. Iglič A, Srakar F, Antolič V. (1993) Influence of pelvic shape on biomechanical status of the hip. Clin Biomech 8:223-224.
5. Jaklič A, Pernuš F (1994) Morphometric analysis of AP pelvic and hip radiographs. In : Zajc B, Solina F (eds.) Proceedings of the third Slovenian electrotehnical and computer science conference. Ljubljana, pp 352-355.
6. Kummer H (1991) Die klinische Relevanz biomechanischer Analysen der Hüftregion. Z Orthop 129: 285-294.
7. Legal H (1987) Introduction to the biomechanics of the hip. In : Tönnis D (ed.) Congenital Dysplasia and Dislocation of the hip. Springer-Verlag Berlin, pp 26-57.
8. Sviridov A I (1983) Anatomija čeloveka. Golovnoe izd., Kiev,Viša škola, pp 64-65.